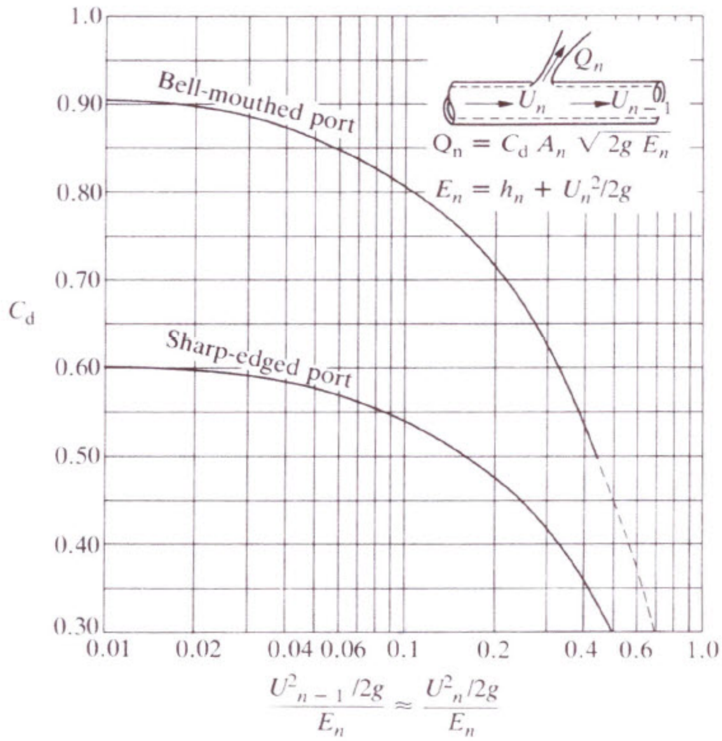
The calculation of discharge from holes or ports in a pipe wall is described in Section 13.12 of 'Internal Flow Systems', by DS Miller. Accutech acknowledges this as the source of the graph below.

The discharge equation is given by:

$$Q_n = C_d\ (\pi\, d_n^2/4)\sqrt{(2gE_n)}$$

Where $E_n = h_n + U_n^2/2g$

and the terms are defined in the graph below.

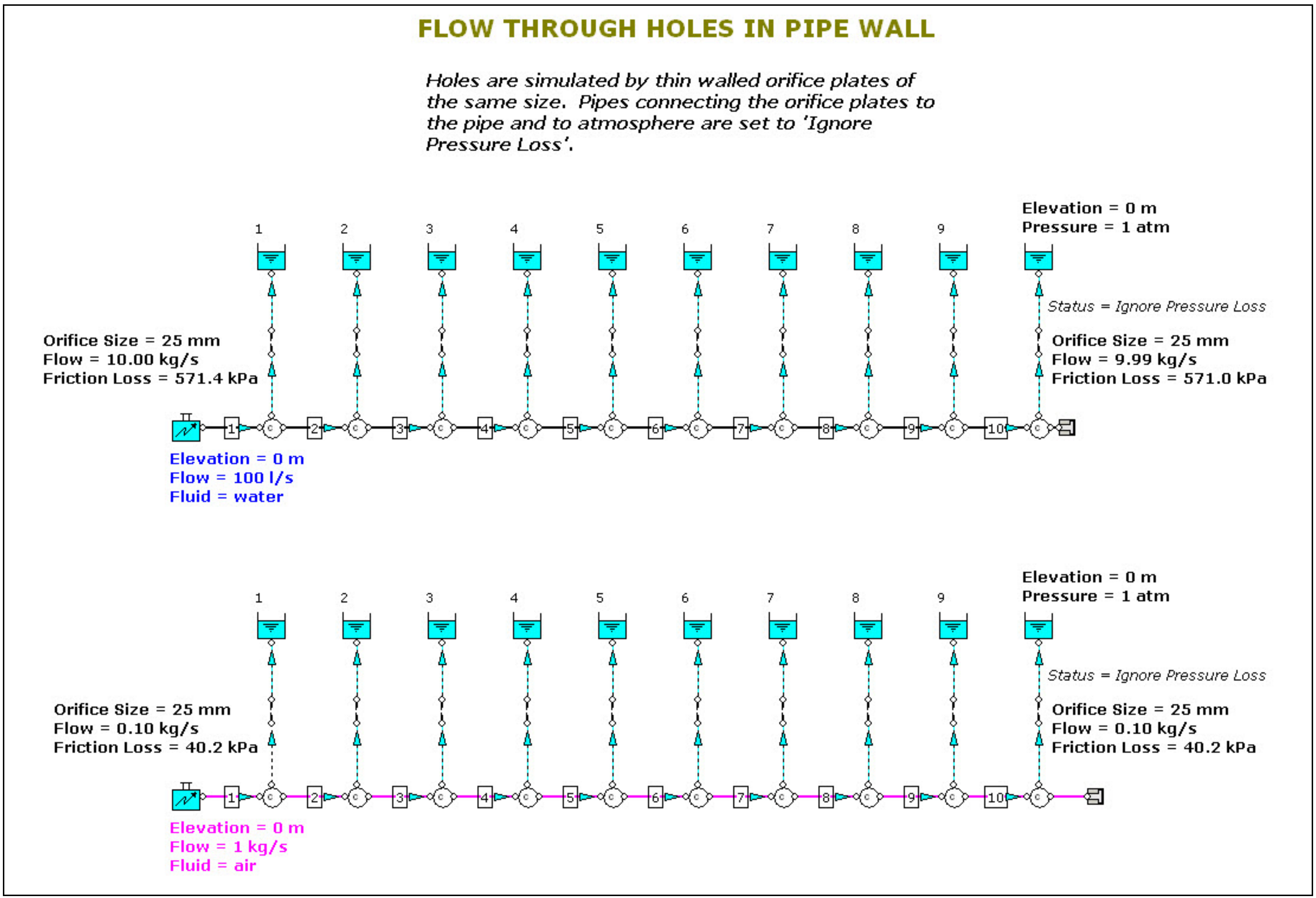


In summary, the Miller method determines the flowrate from each port on the basis of the conditions in the pipe immediately upstream of the port. *FluidFlow3* cannot replicate this method. However, the equation of flow is very similar to that of an orifice plate and this may provide a reasonable solution.

The *FluidFlow3* schematic shown below simulates 10 circular holes in the side of a pipe. The dimensions are the same for each system, viz: pipe - 8" steel, port spacing - 300mm, port diameter 25mm. In the upper model the fluid is water, in the lower – air.

The ports were simulated with a sharp edged orifices connected to the main pipe by pipe of the same diameter as the main pipe, but with these connecting pipes having their status set to "ignore pressure drop".

So the calculation of flow and head loss for each port by *FluidFlow3* is simply based on the head loss across a sharp edged orifice. This compares to the Miller approach, for example Port No. 5, where the flowrate would depend on the flow properties in Pipe Section No.5.



The calculation of head loss across an orifice in *FluidFlow3* is based on ISO 5167 and clearly the arrangement shown does not comply with the conditions of that standard. How close therefore is *FluidFlow3* to the method given in Miller?

Using the export facility to Excel it's possible to export and/or calculate the terms of the above equation for each pipe segment. C_d must be read from the graph and the calculated flowrate compared to that determined in *FluidFlow3*.

For the water flow example shown above values were almost identical when comparing the flowrate calculated in Excel from the pipe flow values upstream of each port with the *FluidFlow3* values at the exit points.

For the air flow the immediate comparison was not so good.

This was because the Miller equation deals in volumetric flowrate which reflected the pressure immediately upstream of each port. Pressure here was clearly higher than that at the outlet to atmosphere. If volume flows were converted to the same pressure base (atmospheric) then *FluidFlow3* values were within about 10% of Miller.

In reality, spacing of ports, thickness of pipe wall, rounding of hole edges, pipe diameter – all could significantly influence the actual flowrate.

This note is only a guide as to how this type of system may be simulated. It is the responsibility of the *FluidFlow3* user to determine if the method described above is suitable for his/her particular application.

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